

ANNUAL REPORT 2004



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TEKNISKA HÖGSKOLAN
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Helsinki University of Technology Networking Laboratory
Teknillinen korkeakoulu Tietoverkkolaboratorio
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ABSTRACT

The research and teaching area of the Networking laboratory focuses on communication networks, in particular network layer, but also end-to-end issues, teletraffic theory, and network economics. Currently the central research problem of the field is leveraging the Internet into a converged service network. This requires novel approaches in managing service quality, charging, security, and service platforms.

The teaching curriculum of the Networking laboratory includes three major subjects: Networking Technology, Teletraffic Theory and Telecommunications Management. Under these subjects we run courses on IP technology, circuit-switched networking, teletraffic theory, service and protocol development, and networking business. The Networking Technology major is also part of the TKK International Master's Program in Telecommunications.

In 2004, the laboratory celebrated its 60-year anniversary and the honorable milestone of 1000 M.Sc. theses. Our staff published 6 international journal papers and circa 30 papers in conferences. One doctoral thesis, 5 licentiate theses and 40 M.Sc. theses were achieved by the students of our laboratory.

In 2004, the laboratory carried on research in several multi-year research projects. The biggest project was the Intelligent Routing Network project (IRoNet), one of the TEKES NETS spearhead projects. Our growing research activity is visible in the financing structure in which the share of Ministry of Education has gradually decreased to 38 percent due to the increased research financing from EU and The Academy of Finland. Also the large number of M.Sc. theses (10) completed in the Netlab research projects results from the increased research activity.

CONTENTS

Abstract	1
Contents	3
1 Introduction	5
1.1 New Thematic Graduate School	7
1.2 International Activities	7
1.3 Social impact of our Activities	7
1.4 Summary	7
2 Personnel 2004	9
2.1 Professors and Docents	9
2.2 Administrative personnel, teachers and assistants	9
2.3 Senior researchers and researchers	9
2.4 Research assistants and trainees	10
2.5 Part-time teachers	11
3 Research projects	13
3.1 AHRAS	13
3.2 ECOSYS	13
3.3 E-NEXT	14
3.4 Euro-NGI	15
3.4 FIT	15
3.4 IRoNet	16
3.5 LATE	17
3.6 LEAD	18
3.7 MobileMAN	18
3.8 NAPS	19
3.9 PAN-NET	20
3.10 TIEVA	21
3.10 WIDENS	21
4 Teaching	23
4.1 General notes on teaching in 2004	23
4.2 Course descriptions	23
4.3 Theses	25
5 Activities	31
5.1 Participation in conferences and meetings	31
5.2 Academic activities	35
5.3 Visits abroad	35
5.4 Foreign visitors in 2004	36
6 Participation in boards and committees	37
6.1 University boards and committees	37
6.2 Other boards and committees	37
6.3 Referee activities	38
Publications	41
A Message by rector Pursula at the Netlab's anniversary	47
B Message by professor Kantola at the Netlab's anniversary	49

1 INTRODUCTION

The highlights of the year 2004 were the laboratory's 60-year anniversary, completion of the large NETS program, and creation of a new graduate school.

The 60-year anniversary was celebrated in March by about 100 people as an event of honorary talks and an exhibition of on-going research and historical items. Rector Matti Pursula congratulated our laboratory for the record cumulative number of 1000 M.Sc. theses during 60 years, but also reminded about the importance of doctoral theses. Professor emeritus Kauko Rahko gave a lively talk on the history of our lab as it evolved from an electronics lab to a telephony lab, and finally to an Internet-driven networking lab. M.Sc. Tapio Karjalainen (executive vice president, Elisa Oyj) highlighted the key role of our lab in building the telecluster miracle in Finland and encouraged us to keep the close ties with the industry.

NETS was the largest research program ever funded by the National Technology Agency TEKES. Our IRoNet project was one of the four spearhead projects in NETS and had a big impact on our thesis production. Also several new projects were initiated during 2004 including Wireless Deployable Network System (WIDENS), Analysis and Design of Advanced Multiservice Networks Supporting Mobility, Multimedia, and Internetworking (PAN-NET), Optimal Rules for a Leading Mobile Data Market (LEAD), Techno-economics of Integrated Communication Systems and Services (ECOSYS), and two EU networks of excellence (E-NEXT, Euro-NGI).

The first intake of International students into the Networking technology major in 2003 has brought an additional international momentum to our course portfolio in 2004.

Many researchers of the Laboratory achieved academic degrees, including the degree of the Doctor of Science in Technology by Esa Hyytiä. The number of M.Sc. theses earned by our students in 2004 was 40, which is high but clearly less than the all-time-high, 60 theses. For three and a half professor man-years during 2004 the number of supervised M.Sc. theses continues to be excessively high compared to the TKK average of less than 5 theses per professor. We expect a high thesis workload per professor to continue even though our plan includes the increase of professor head count and decrease of student intake. The impact of these actions is likely to take several years.

The positive development in project financed research activities is also visible in the Laboratory spending presented in Figures 1.1 and 1.2. Figure 1.1 shows the diversity of sources of research funding and Figure 1.2 the overall development for the past few years.

In addition to the basic government budget, the government directed Academy of Finland and TEKES are the largest sources for research funding.

The Laboratory had a development day focusing on the employee survey feedback and teaching issues. Two lab-wide social events were organized during the year: a summer trip to Kaivopuisto and the traditional Christmas party, this time in the historical Villa Kivi, Helsinki.

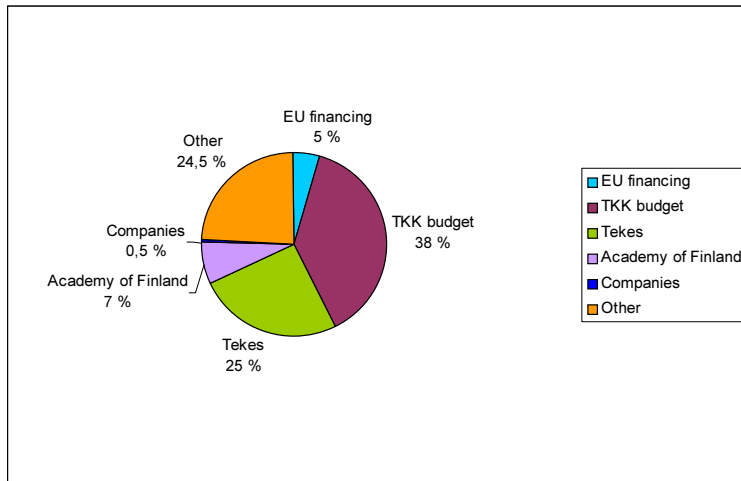


Figure 1.1: Financing of the Networking Laboratory 2004

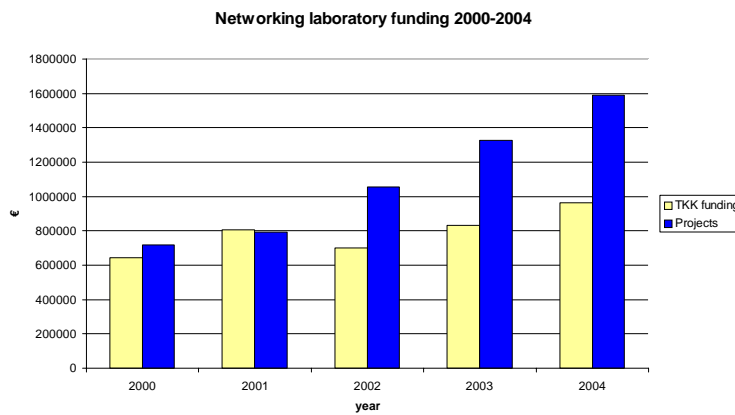


Figure 1.2: Financing of the Networking Laboratory 1999-2004

1.1 New Thematic Graduate School

The kick-off of the Graduate School on Networks for Information Society (GSNIS), a new thematic graduate school, was held in November. GSNIS was founded by the technical universities of Helsinki and Tampere, and the National Defense College, in order to create new funding opportunities for doctoral students focusing on network-driven cross-disciplinary research topics. GSNIS will complement GETA which is an established and more electronics-driven graduate school covering the traditional scientific domains of telecommunications.

Based on the university seed funding GSNIS was able to take about 20 doctoral students in 2004. Several students of our laboratory were approved to the program in the first request for applications.

1.2 International Activities

Internationalization of the laboratory continues steadily. The Networking Technology major is now a part of the TKK International Master's program in Telecommunications. Roughly 60% of our courses were lectured in English (not including individual assignments and labworks). The courses taught in English include nearly all Ph.D level courses and seminars as well as the Master's level courses needed in the International Major. Already 80 percent of the Master's theses were written in English.

We are members of two European Networks of Excellence, Euro-NGI in the area of teletraffic theory, performance analysis and network design, and E-NEXT in the area of networking technology.

We received 28 foreign research visitors to our laboratory and we sent 6 research visitors to foreign laboratories.

1.3 Social impact of our Activities

Our biggest impact no doubt is the production of networking experts, both masters and doctors, to the telecommunications market. Another major impact comes from our research projects.

However, according to the new University law the universities are assigned the so called third task in parallel with research and higher education. The task is to contribute to the development of welfare and the society at large. As one consequence the universities are allowed to create separate legal units. A special TKK fund is being ramped up to facilitate funding for university spin-offs. We hopefully will be able to exploit this new opportunity.

Several persons of the laboratory are also actively contributing via newspaper articles, policy talks, scientific review processes, national funding committees, and other kinds of professional volunteer projects.

1.4 Summary

We finish the year with positive expectations on the future. National decision makers have realized the importance of technical universities in fertil-

izing the success of the Finnish telecluster. They also have promised to take actions to improve the shortage of teaching resources and the unbalanced quantity-driven performance measurement policy.

The laboratory is achieving a situation of four full-time professors. A new full-time professor, Dr. Jörg Ott, is about to start in the early 2005. This is an opportunity to welcome Dr. Ott and also to thank Dr. Jorma Jormakka for his significant contribution in the laboratory as a part-time professor between 2000-2005.

The laboratory will continue steadily toward a more international profile, a larger output of high-quality doctoral theses, and a stronger industrial and public funding base. This is realistic assuming that the government and TKK maintain their positive approach to new professorships and resources.

March 3rd, 2005

Heikki Hämmäinen

2 PERSONNEL 2004

Laboratory staff and personnel can be reached by e-mail with address: first-name.lastname@netlab.hut.fi

2.1 Professors and Docents

Hämmäinen, Heikki	D.Sc. (Tech.), Professor, head of the laboratory (2004)
Jormakka, Jorma	Ph.D., Professor
Kantola, Raimo	D.Sc. (Tech.), Professor, head of laboratory (2005)
Virtamo, Jorma	D.Sc. (Tech.), Professor
Chakraborty, Shyam	D.Sc. (Tech.), Docent
Kilkkki, Kalevi	D.Sc. (Tech.), Docent
Pirinen, Aulis	Ph.D., Docent
Raatikainen, Pertti	D.Sc. (Tech.), Docent
Rahko, Kauko	D.Sc. (Tech.), Professor emeritus

2.2 Administrative personnel, teachers and assistants

Erke, Tapio	M.Sc., Laboratory engineer, on leave
Halkilahti, Raija	Department secretary
Hänninen, Arja	Administrative assistant
Kosonen, Vesa	M.Sc., University teacher
Matinlauri, Anni	Student adviser
Nupponen, Esko	Senior laboratory supervisor
Pitkäniemi, Kimmo	PC support
Patana, Sanna	Department secretary, on leave
Willa, Kirsi	Assistant

2.3 Senior researchers and researchers

Aalto, Samuli	Ph.D.
Hyytiä, Esa	D.Sc. (Tech.)
Karvo, Jouni	D.Sc. (Tech.)
Kuusela, Pirkko	Ph.D.
Lassila, Pasi	D.Sc. (Tech.)
Murgu, Alexandru	Ph.D.
Töyli, Juuso	D.Sc. (Tech.), D.Sc. (Econ.)
Zhang, Peng	Ph.D.

Antila, Johanna	M.Sc.
Bai, Xiaole	M.Sc.
Beijar, Nicklas	Lic.Sc. (Tech.)
Costa-Requena, Jose	Lic.Sc. (Tech.)
Daskalova, Evgenia	M.Sc.
Ilvesmäki, Mika	Lic.Sc. (Tech.)
Jussila, Ville	M.Sc.
Juva, Ilmari	M.Sc.
Kaleelazhicathu, Renjish	M.Sc.
Kalm, Juha	M.Sc.
Kamppari, Sauli	M.Sc.
Karppinen, Lauri	M.Sc.
Kiiski, Annukka	M.Sc.
Koskinen, Henri	M.Sc.
Leino, Juha	M.Sc.
Luoma, Marko	Lic.Sc. (Tech)
Matuszewski, Marcin	M.Sc.
Mölsä, Jarmo	Lic.Sc. (Tech.)
Nieminen, Laura	M.Sc.
Nyberg-Oksanen, Eeva	Lic.Sc. (Tech.)
Peuhkuri, Markus	Lic.Sc. (Tech.)
Paju, Antti	M.Sc.
Penttinen, Aleks	M.Sc.
Sarala, Risto	M.Sc.
Smura, Timo	M.Sc.
Suominen, Niko	M.Sc.
Susitaival, Riikka	Lic.Sc. (Tech.)
Töyrylä, Piia	M.Sc.

2.4 Research assistants and trainees

Apilo, Olli	Ayyash, Mohammad
Basaure, Arturo	Creado, Jarrod
Gröhn, Antti	Huttunen, Jari
Hänninen, Juha	Jaskiewicz, Daniel
Järvinen, Juha	Kaikkonen, Sampo
Liu, Shuping	Mahanen, Petri
Matinlauri, Anni	Merger, Mikko
Pitkänen, Mikko	Ralli, Timo
Simola, Oskari	Tallberg, Mathias
Vermaja, Juha	Viipuri, Timo
Wang, Yin	Wu, Kaiyuan
Zhao, Shushan	

2.5 Part-time teachers

Huguet Prunera, Josep	S-38.121 Routing in Communication Networks
Jääntti, Riku	S-38.193 Wireless networks
Nardone, Massimo	S-38.153 Security in Communication Protocols
Pärssinen, Juha	S-38.157 Protocol Design
Seppänen, Kari	S-38.165 Switching Technology

The guest lecturers and the program in S-38.001 Telecommunications Forum are shown in Figure 2.1 on the following page.



HELSINKI UNIVERSITY OF TECHNOLOGY
Networking Laboratory

What's HOT in telecommunications?

Telecom Forum '2004

An open house studia generalia seminar on telecommunications

PROGRAM 2004

- 28.09. Jorma Mellin, Network Manager, Song Networks
Peer-to-Peer Networking - Phenomenon and Impacts to Carriers
- 05.10. Ulf Grindgärds, Chief Executive Officer, Seutuverkot
Community Networks Boosting Broadband Access
- 12.10. Jukka T. Bergqvist, Dr., Senior Vice President, Nokia
Evolution of Mobile Networks
- 19.10. Jari Elo, Director, TellaSonera Finland
Telecommunications in Large-scale Events
- 26.10. Mikko Terho, Senior Vice President, Nokia
Standardization, de Facto Standardization, and Technical Architectures
- 02.11. Petri Helenius, Chief Executive Officer, Rommon
Evolution of Internet Traffic
- 09.11. Juha Juosila, Director, MTV Interactive
Network as a Content Channel
- 16.11. Lauri Valjakka, Chief Executive Officer, E-3 Systems
Digital Distribution of Music
- 23.11. Seppo Borenus, Director, Tellabs
IP and Ethernet - Master and Slave?
- 30.11. Harri Pursiainen, Director General, Ministry of Transport and Communications
Regulation for Convergence

Lectures are held at 17:15 - 19:00 in the lecture hall S4, 2nd floor of the Department of Electrical and Communications Engineering Helsinki University of Technology, Otakaari 5A. Bus 102 from Helsinki.

More info: <http://www.netlab.hut.fi/opetus/s38001/>

Figure 2.1: Telecom Forum 2004

3 RESEARCH PROJECTS

3.1 AHRAS

Project leader: Jorma Virtamo **Researchers:** Esa Hyytiä, Henri Koskinen, Pasi Lassila, Laura Nieminen, Aleks Penttinen

Project AHRAS concentrates on the routing and other traffic related issues in wireless ad hoc networks. The project that was started in 2001 continues to the end of 2005. The work is funded by the Finnish Defence Forces Technical Research Centre. During year 2004, the project addressed network connectivity, node mobility, multicast routing, and performance analysis in ad hoc networks. Some of these problems were jointly studied in the projects NAPS and FIT.

The most commonly used elementary mobility model, known as RWP, has been analyzed and analytical results have been obtained for the stationary spatial distribution of the mobile nodes. These results were applied for evaluating connectivity properties of ad hoc networks, where the nodes move according to RWP. Additionally, the formula giving the node distribution in an arbitrary convex area for RWP nodes was extended to 3-dimensional space (and higher dimensions as well).

Studying temporal dynamics, on the other hand, requires explicit simulation, which was the motivation for implementing AHN, an ad hoc network simulation platform. Several quantities characterizing the temporal behaviour of the connectivity were determined on the basis of the simulations. Also, mobility models were further developed, and a two-level RWP model was introduced as a group mobility model for simulation purposes.

The multicast routing problem entails finding a tree consisting of sequential transmissions to connect a source to several destinations. In the project, a distributed algorithm was proposed for minimizing the number of transmissions in such a tree.

Finally, the flow-level performance of wireless multi-hop networks was brought within reach of mathematical analysis. This was enabled by the generalization of an existing resource allocation scheme from the context of fixed networks.

The manuscript of a Licentiate thesis was completed in the project in 2004.

3.2 ECOSYS

Project leader: Heikki Hämmäinen, Renjish Kaleelazhichathu **Researchers:** Timo Smura

ECOSYS (Techno-economics for Intergrated Systems and Services) is a 3-year international project (2004-2007) part of the EUREKA/CELTIC program. The project covers a set of operator-centric techno-economic investment issues related to fixed, mobile, and convergent networks. Work-packages include traffic forecasting, development of techno-economic analysis methodology and tools, and application of these on specific busi-

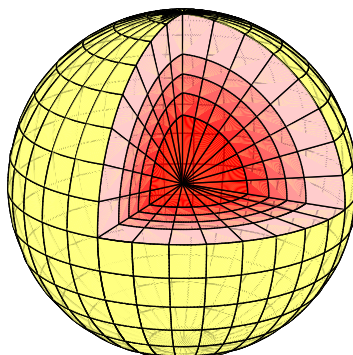


Figure 3.1: Pdf of a node moving according to RWP model in unit sphere. Each section represents a probability mass of 20%. [17]

ness cases. Our team focuses on mobile network related topics.

During 2004 we analyzed mobile forecasts, designed a forecasting structure, analyzed new mobile business models, designed a business model description methodology, defined a service classification, and used the ECOSYS tool to analyze tentatively a context-specific 3G/WLAN business case. All these research items are preparation for the techno-economic cases to be analyzed later on. The ECOSYS short list of target business cases so far includes 1) comparison of unlicensed vs licensed radio spectrum, 2) mobile VoIP evolution scenarios, 3) mobile QoS evolution scenarios, 4) wide-area wireless scenarios (WCDMA vs WiMAX).

3.3 E-NEXT

Project leader: Raimo Kantola **Researchers:** Marko Luoma, Heikki Hämmäinen, Markus Peuhkuri, Mika Ilvesmäki, Johanna Antila, Nicklas Beijar, Renjish Kaleelazhichathu, Marcin Matuszewski, Evgenia Daskalova

E-NEXT is a Network of Excellence in the Sixth EU Framework Program. The purpose of E-NEXT is to advance collaboration between the Networking Technology Laboratories of the participating Universities in Research and Doctoral studies. E-NEXT organizes conferences and workshops and runs joint work group activities in the areas of Ambient and Mobile Networking, Scalable Networking, Self-Aware Networking, Content Networking and Service Aware Networking. E-NEXT also has organized its own Doctoral School of Advanced Topics In Networking (SATIN).

A NoE like E-NEXT does not pay for the research work itself, it only has a budget for covering cooperation expenses.

During 2004 we participated in several E-NEXT work group activities, conference organization activities and in organizing the SATIN Doctoral School. We also have a joint research project with our E-NEXT partners on Metropolitan Area Ad hoc Networks (MobileMAN).

3.4 Euro-NGI

Project leader: Jorma Virtamo **Researchers:** Samuli Aalto, Esa Hyytiä, Ilmari Juva, Henri Koskinen, Pirkko Kuusela, Pasi Lassila, Juha Leino, Eeva Nyberg-Oksanen, Aleksi Penttinen, Riikka Susitaival

Euro-NGI is one of the Network of Excellences of the EU Sixth Framework Programme. The purpose of a NoE is to foster, in a broad sense, collaboration between the participating institutions and integration of their research activities. The end of the acronym, NGI, stands for Next Generation Internet. Euro-NGI was started in December 2003 and continues for three years. It is a very large network including 58 partners, mostly from the academia but also a few partners from the industry are involved.

Researchers of the Networking Laboratory have participated in many activities of Euro-NGI. In particular, two D.Sc. students attended the Euro-NGI summer school that was organized by the Otto-Friedrich University, Bamberg, Germany. Also two workshops were attended by the researchers, one at Schloss Dagstuhl in Germany (Mobility and Wireless in EuroNGI) and one in Edinburgh, UK (Spatial stochastic modelling, with applications to communications). One D.Sc. student made a 3-month research visit to the University of Thessaly. Researchers also contributed respective sections to two deliverables that were submitted in June. Researchers served as reviewers of several papers submitted for the Euro-NGI 2005 conference to be held in Rome in April 2005. One paper from the laboratory was accepted for this conference. Networking Laboratory was also a partner in two joint research proposals within Euro-NGI for year 2005. Both of the proposals were accepted, leading to even more intense cooperation in 2005.

FIT: Future Internet – Traffic Handling and Performance Analysis

Project leader: Jorma Virtamo **Researchers:** Samuli Aalto, Esa Hyytiä, Ilmari Juva, Juha Leino, Riikka Susitaival

This was the last year of the three-year project funded by the Academy of Finland. At a general level, the objective of the project was to study methods for traffic handling in the Internet and methods for providing Quality of Service (QoS) and QoS differentiation, as well as to develop methods for analyzing the performance of such systems. The specific topics studied in 2004 were as follows:

The work on balanced fairness (BF), a novel insensitive resource sharing scheme, was continued. A new computational algorithm was developed in collaboration with T. Bonald from France Telecom R&D. The principle of BF was also extended to routing. Jointly balanced routing and bandwidth sharing policies were found by formulating the problem as an LP problem. An algorithm for finding the policies in a simple network was developed in collaboration with M. Jonckheere from France Telecom R&D during a visit to the Mittag-Leffler Institute in Stockholm.

The simple adaptive load balancing mechanism, having been developed under several projects, was applied for systems using OSPF routing, where traffic can be routed along the shortest paths only. It was found, that we can improve the performance of the network significantly without unde-

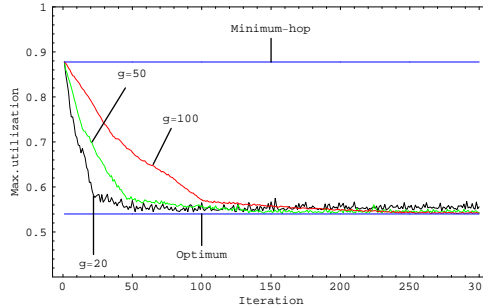


Figure 3.2: The maximum link utilization as a function of the number of iterations in a numerical evaluation run of an adaptive load balancing algorithm.

sired link weight updates by changing the splitting of traffic to the shortest paths.

At the transport level, modern broadband networks utilize optical technology, which poses different type of traffic handling problems. The performance of MAC protocols in an optical ring network using optical burst switching was studied by analytical models.

Many traffic handling operations at the network level require knowledge of the current traffic demands between different origin-destination pairs. Estimating the traffic matrix on the basis of link load measurements, however, is a strongly under determined problem and poses a big challenge. In the project, a Bayesian maximum likelihood method for solving the problem was studied and an iterative algorithm was derived for deriving the estimate.

The performance analysis of data traffic in wireless systems is currently one of the most central research topics. In the project, the flow throughput perceived by a finite population of users moving within a cell was investigated. An analytical approach was found feasible in the limits of very fast and very slow motion. The performance results were compared to those presented in the literature for an infinite population of users.

Results derived in other projects concerning the distribution of users moving according to so-called random way-point model, were applied to obtain several quantities of interest in cellular systems, such as the hand-over rate, i.e. rate of crossings of cell boundaries.

One D.Sc. thesis, one Lic.Sc. thesis and one M.Sc. thesis were completed within the project. The D.Sc. and Lic.Sc. theses were partly based on work done in other projects in previous years.

IRoNet – Intelligent Routing Network

Project leader: Raimo Kantola **Researchers:** Johanna Antila, Xiaole Bai, Evgenia Daskalova, Antti Gröhn, Jari Huttunen, Mika Ilvesmäki, Ilmari Juva, Renjish Kaleelazhichathu, Pasi Lassila, Marko Luoma, Anni Matinlauri, Marcin Matuszewski, Antti Paju, Timo Smura, Riikka Susitaival, Piia Töyrylä, Yin Wang, Peng Zhang

IRoNet studied the additional intelligence that is needed in the IP network in order to support Quality of Service. IRoNet scope covered the packet forwarding plane, the control plane and the management plane functionality needed in an IP network in order to fulfill the operator's popular vision of All-IP network and to provide a QoS enhanced Internet. In particular, the main areas of interest were traffic classification, modelling of the forwarding plane algorithms, routing and management support for the whole system. The project used mathematical modelling of the forwarding plane mechanisms and the behavior of traffic streams, simulations of protocols and algorithms, traffic and performance measurements and prototyping of the mechanisms and algorithms particularly in the control and management planes. The project started in 1/2002 and will end in early 2005.

During 2004 we continued refining the methodology of traffic classification and building a large QoS prototype in which we can verify our earlier results on traffic classification and policy based management of QoS. In our prototyping and prototype based controlled measurement research we gained new insights in the capabilities of many new and well-known mechanisms that are used for implementing QoS. Using simulations we studied novel packet scheduling algorithms, in particular delay estimation for adaptive scheduling. In QoS routing the focus was on simulating the potential of Traffic Engineering using routing to allocate traffic onto the network, prototyping the concept of Multi-Class Routing and on prototyping a solution for centralized intra-domain routing. In multi-class routing the idea is that each DiffServ traffic class is routed separately and has its own routing table in each of the routers. Each class may also use a different routing algorithm.

In Ironet in 2004 we started collecting and processing traffic traces from FUNET in close collaboration with the CSC that runs the Finnish University Network. We now have an abundance of traffic trace material for developing our traffic classification methodology and for doing statistical studies on Internet traffic. The traces pose significant processing requirements due to the data volumes but we believe this a good problem to have.

In IroNet we developed a hardware solution for synchronizing the router clocks in the research prototype. The initial solution is based on GPS and allows to time stamp events in the prototype with the accuracy of some tens of microseconds. A more advanced hardware solution is being developed and is expected to give a ten fold improvement to the accuracy.

3.5 LATE

Project leader: Jorma Jormakka **Researchers:** Juha Kalm and Mikko Merger

LATE project focuses on simulation-based performance evaluation of wireless LANs (IEEE 802.11) on different usage scenarios. Using both normal IPv4 and Mobile IPv6 on WLAN environment was studied using simulation models built for ns2 simulator.

3.6 LEAD

Project leader: Heikki Hämäläinen **Researchers:** Annukka Kiiski, Timo Ralli, Mathias Tallberg, Juuso Töyli

LEAD (Optimal Rules for a Leading Mobile Data Market) is a 2-year national project (2004-2005) funded by TEKES/NETS, Ficora, Nokia, Sonera, Elisa, and DNA. The general plan is to identify, analyze, and better understand the techno-economic bottlenecks of the Finnish mobile data services market. This research is done together with the key market players. Research methodology is based on literature studies, expert interviews, frequent reviews with partners, technology scenario modelling, and construction of a mobile operator business game.

During 2004 we studied a set of reference markets and identified aspects that distinguish the Finnish market from some other markets. Out of the many candidates we then focused on a small set of issues: handset-to-subscription bundling, national roaming for WLAN, and virtual operators. Handset bundling is a relevant topic because Finland is one of the few markets which prohibits bundling. Our study so far suggests that prohibition of handset bundling is a more complex issue than expected and deserves a deeper analysis. National WLAN roaming is relevant for our research because of its high potential of added-value and because it is likely to create a reference business model for future unlicensed wireless access. We have so far identified the alternative market scenarios. Virtual operators together with number portability have induced a new level of mobile competition in Finland. Unfortunately, according to our study, this competition has remained within the scope of traditional services, without promoting the innovation of new data services. This situation is somewhat unique to Finland and challenges the regulator's basic assumption: competition should promote innovation.

3.7 MobileMAN

Project leader: Raimo Kantola **Researchers:** Jose Costa-Requena, Nicklas Beijar

MobileMAN is an European project investigating the potential of the Mobile Ad hoc NETWORK (MANET's) paradigm. We are participating in this project with multiple European research entities such as CNR (National Italian Research institution), Eurecom, Cambridge University, SUPSI (Switzerland University Polytechnic). The project aims to define and develop a metropolitan area, self-organizing, and totally wireless network called the Mobile Metropolitan Ad hoc Network (MobileMAN).

The main technical outputs expected of this project include:

1. Development, validation, implementation and testing of the architecture, and related protocols, for configuring and managing a MobileMAN. The research is conducted spanning all layers in the networking hierarchy. Our research combines advanced communications and networking research with basic research.

2. Physical implementation of this architecture for lower layers (i.e., wireless technologies). This will be done by improving the existing IEEE 802.11 wireless technologies for dealing with bursty access environments as self-organized networks.
3. Integration of applications on top of the self organized network.
4. Validation of the self-organizing paradigm from the social and economic standpoint.

During this year, we continued the development of the ad hoc routing testbed that is an integral part of the three-year research plan. A routing testbed is useful because simulations seem to produce rather arbitrary results for the benefits of each routing protocol being evaluated.

The prototype runs on iPaq palmtops that have Linux OS. The nodes can run several routing protocols. The currently operational routing protocols are AODV and OLSR, and we are working on ZRP. The nodes are grouped into "smart" and "dummy" nodes. Smart nodes can provide additional services, such as a gateway to a base station or an Access Point. Our goal is to implement service discovery in the prototype.

During this year we have implemented the node classification (i.e. smart, dummy nodes) for creating Ad Hoc backbone. We have performed field testing with several nodes and routing protocols. We have also been implementing and testing SIP and VoIP on top of the routing package.

3.8 NAPS

Project leader: Jorma Virtamo **Researchers:** Olli Apilo, Jouni Karvo, Henri Koskinen, Shuping Liu

NAPS (Networking and Architecture for Proactive Systems) is a 3-year project (2003-2005) funded by the Academy of Finland. It is part of the research programme on Proactive Computing (PROACT). The research consortium of NAPS is coordinated by Helsinki Institute for Information Technology, Basic Research Unit, with sub-project at the Networking Laboratory (TKK) and the Laboratory for Theoretical Computer Science (TKK). In 2004, the following topics were addressed:

The connectivity of a randomly dispersed sparse sensor network can be improved by placing additional nodes in the network, forming connections between separate clusters of connected nodes. We have defined two problems: minimizing the required number of additional nodes for achieving a connected network, and maximizing utility from a given number of additional nodes in the case complete connectivity cannot be established. The problems are too complex to allow an exact solution. Therefore, computationally efficient heuristic algorithms were proposed: a minimum spanning tree algorithm, and two greedy algorithms. The performance of these algorithms was evaluated by simulations.

The problem of full sensor coverage of a given target area with randomly located sensors was studied. This problem is closely related to the k -connectivity problem of an ad hoc network and reduces to finding the distribution of a well-defined threshold range. Thus the method for predicting

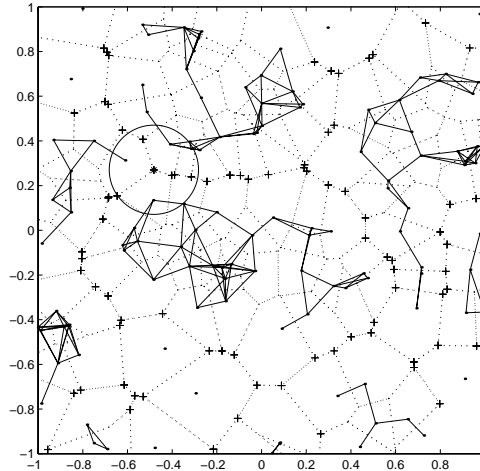


Figure 3.3: Illustration of the node placement problem in sensor networks. The greedy algorithm placing the additional nodes is based on Voronoi tessellations. [38]

k -connectivity developed before could be applied to predicting full coverage; the existing asymptotic results on coverage problems can be interpreted as the asymptotic distribution of the threshold range for full coverage.

The work started in the FIT project on the performance analysis of data traffic in wireless systems was continued in the NAPS project with a shift of focus towards multi-cell scenarios.

3.9 PAN-NET

Project leader: Jorma Virtamo **Researchers:** Samuli Aalto, Pirkko Kuusela, Pasi Lassila, Eeva Nyberg-Oksanen, Kaiyuan Wu

PAN-NET is a joint project with VTT Information Technology and represents the main Finnish contribution to the European COST 279 Action, “Analysis and Design of Advanced Multiservice Networks Supporting Mobility, Multimedia, and Internetworking”. The reporting period was the first year of the PAN-NET project, planned to last three years. The project is funded by Tekes and industrial partners NRC and Elisa. The focus in 2004 was on the performance problems of wireless networks for data traffic.

TCP dynamics in wireless environment was investigated. In particular, the work focused on evaluating the goodput of a single TCP source on a low bandwidth wireless link experiencing sudden increases in RTT, so-called delay spikes. Such spikes trigger spurious timeouts that reduce the TCP goodput. The dependence of the goodput on the duration of the delay peak and on the inter-peak time distribution was worked out.

Theoretical work on differentiated scheduling of the “mice” and the “elephants” by flow prioritization was continued. This work was started already in a previous project, in collaboration with U. Ayesta from INRIA, Sophia Antipolis. New results relating to systems with multiple thresholds

were derived. A packet level realization, RuN2C, of an ideal flow level scheduling principle with one threshold, so-called PS+PS scheduling, was implemented and studied by simulations.

Optimal load balancing policy between two neighbouring base stations with overlapping coverage areas was worked out by using MDP theory. The dynamic decision problem is to find the optimal routing (either via BS1 or via BS2) of an arriving flow destined to the overlap area, given the number of other flows in progress. As optimization criterion the average response time of a flow was used. The manuscript of a M.Sc. thesis was completed.

3.10 TIEVA

Project leader: Jorma Jormakka **Researchers:** Marko Luoma, Markus Peuhkuri, Mikko Pitkänen, Timo Viipuri, Risto Sarala, Ville Jussila

TIEVA is a research project for analyzing and development of network layer operations of a large service provider network. Network is analyzed by using distributed passive and active measurements. Distributed passive network measurement is a suitable tool for constructing comprehensive picture of network traffic. Active measurements on the other hand reveal the operational level of the network. Based on the information gathered from these measurements steps for the network development are constructed. These steps are validated through simulations utilizing models derived from the network measurements. Usual development steps contain dimensioning, changes of topology, and changes of traffic control within the network. The overall goal of TIEVA project is to create a network that can withstand sudden and unusual overloads, errors and traffic patterns. To facilitate this background research on routing stability and network path restoration is executed.

During the year 2004 two M.Sc. theses were done on the areas of transient state analysis of OSPF routing protocol, and traffic analysis and modelling of IP core networks.

WIDENS – Wireless DEployable Network System

Project leader: Raimo Kantola **Researchers:** Daniel Jaskiewicz, Jouni Karvo, Shushan Zhao

The purpose of WIDENS is to design, prototype and validate a vertically integrated rapidly deployable and scalable communication system for future public safety, emergency and disaster applications.

The project focuses on designing a single hot spot, which can be easily deployed, optimized for high bitrate throughput (over 2Mbit/s) and interoperable with existing core networks and present private mobile radio systems (such as TETRA and Tetrapol).

The system concept is based on ad hoc network technologies, and the technological approach focuses on adaptations of existing technologies for the purposes of meeting the public safety requirements. The target terminal nodes will include both physical, link and network routing layers, and will feature asynchronous and synchronous high bitrates, direct mode group communications, strong authentication and confidentiality and quality of service.

The project will support the strong on-going European involvement in the joint ETSI/TIA standardization initiative MESA (Mobile Broadband for Emergency and Safety Applications). The design and prototype developments will be contributed to the MESA standardization process and will shape the future of private mobile communication systems.

4 TEACHING

4.1 General notes on teaching in 2004

We are responsible for three major subjects in the TKK degree program of Communications Engineering. They are Networking Technology, Teletraffic theory and Telecommunications Management. The last one is produced jointly with the Department of Computer Science and Engineering and the Department of Industrial Engineering and Management.

During 2004 the Bologna process has proceeded rapidly and has taken planning resources. While this big change is being prepared current development of the existing degree programs has slowed down.

In the course S-38.001 Telecommunication Forum many visiting lecturers shared their views on the evolution of telecommunications industry. The course was well-attended and the collection of presenters formed a very good cross-section of the industry. (See also Figure 2.1).

4.2 Course descriptions

This is the full list of courses in our curriculum:

Studia generalia:

- S-38.001 Telecommunications Forum (Telecommunications Forum)

Basic courses for all students studying telecommunications:

- S-38.105 Principles in Communication Engineering (Tietoliikennetekniikan perusteet)
- S-38.145 Introduction to Teletraffic Theory (Liikenneteorian perusteet)

Courses concerning communications and networks:

- S-38.115 Signaling Protocols (Televerkon merkinannot)
- S-38.165 Switching Technology (Välitystekniikka)
- S-38.180 Quality of Service in the Internet (Palvelunlaatu Internetissä)
- S-38.188 Communications Networks (Tietoliikenneverkot)
- S-38.192 Network Service Provisioning (Verkkopalvelujen tuotanto)
- S-38.193 Wireless networks (Langattomat verkot)
- S-38.121 Routing in Communication Networks (Reititys tietoliikenneverkoissa)

Courses on Networking Business:

- S-38.041 Networking Business (Tietoverkkoliiketoiminta)
- S-38.042 Seminar on Networking Business (Tietoverkkoliiketoiminnan seminaari)
- S-38.045 Special Assignment on Networking Business (Tietoverkkoliiketoiminnan erikoistyö)

Courses on Teletraffic Theory:

- S-38.148 Simulation of Data Networks (Tietoverkkojen simulointi)

Courses on protocols and services:

- S-38.151 Service Creation and Management (Palvelukehitys ja hallinta)
- S-38.153 Security in telecommunications (Tietoliikenteen tietoturva)
- S-38.157 Protocol Design (Protokollasuunnittelu)
- S-38.158 Protocol Design, practical assignment (Protokollasuunnittelun harjoitustyö)

Seminars, laboratory works, special assignments:

- S-38.133 Laboratory course on Networking Technology (Tietoverkkotekniikan laboratoriotyöt)
- S-38.138 Networking Technology, special assignment (Tietoverkkotekniikan erikoistyö)
- S-38.203 Project course on Networking Technology (Tietoverkkotekniikan projektityö)
- S-38.310 Thesis Seminar on Networking Technology (Tietoverkkotekniikan diplomityöseminaari)

Postgraduate courses include:

- S-38.030 Postgraduate Course on Networking Technology (Tietoverkkotekniikan lisensiaattikurssi)
- S-38.141 Teletraffic Theory (Teleliikenneteoria)
- S-38.143 Queueing Theory (Jonoteoria)
- S-38.149 Postgraduate Course in Teletraffic Theory (Teleliikenneteorian lisensiaattikurssi)
- S-38.205 Individual Course on Networking Technology (Tietoverkkotekniikan yksilöllinen opintojakso)
- S-38.215 Special course on Networking Technology (Tietoverkkotekniikan erikoiskurssi)
- S-38.360 Research Seminar on Networking Technology (Tietoverkkotekniikan tutkijaseminaari)

4.3 Theses

The key results of teaching in the Networking Laboratory in 2004 can be summarized as

- 40 Master's theses
- 5 Licentiate theses, and
- 1 Doctoral dissertation

The development of thesis production is shown in Figure 4.1

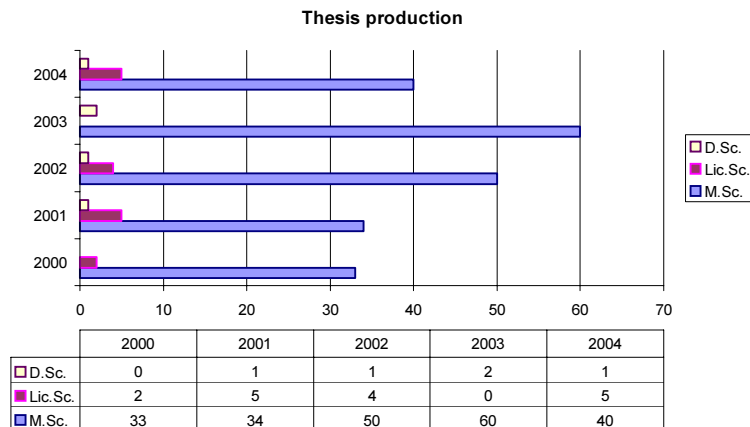


Figure 4.1: Thesis production 1998-2004

Doctor of Technology

Esa Hyytiä Resource Allocation and Performance Analysis Problems in Optical Networks

Optical networks pose a rich variety of new design and performance analysis problems. Typically, the static design problems belong to the field of combinatorial optimisation, whereas decision-making and performance analysis problems are best treated using appropriate stochastic models. This dissertation focuses on certain issues in resource allocation and performance evaluation of backbone wavelength-routed (WR) networks and metropolitan area optical burst switching (OBS) networks. The first two parts of the thesis consider heuristic algorithms for the static routing and wavelength assignment (RWA) and logical topology design (LTD) problems that arise in the context of WR networks. The third part of the thesis studies the dynamic control problem where connection requests, i.e. lightpath requests, arrive according to a certain traffic pattern and

the task is to establish one lightpath at a time in the WR optical network so that the expected revenue is maximised or the expected cost is minimised. In this thesis, the dynamic RWA problem is studied in the framework of Markov decision processes (MDP). The last part of the thesis considers OBS networks, which represent an intermediate step towards full optical packet switching networks. In OBS networks, the data are transferred using optical bursts consisting of several IP packets going to the same destination. On the route of the burst, temporary reservations are made only for the time during which the burst is transmitted.

Licentiate of Technology

Jani Lakkakorpi A Flexible and Adaptive Connection Admission Control Framework for Differentiated Services Access Networks

This thesis presents connection admission control algorithms to be used in Differentiated Services access networks - which are usually the "bottlenecks" of a connection. The presented algorithms are designed for an improved "Bandwidth Broker" server from which the end-users request bandwidth reservations. The suggested algorithms combine parameter-based and measurement-based admission control, which makes it possible to give stricter QoS guarantees to some traffic classes than others.

Nicklas Beijar Telephony Routing with Support for Number Portability in Interconnected Circuit and Packet Switched Networks

The thesis examines the problems of routing, gateway location and number portability in interconnected circuit-switched and IP telephony networks. Since these problems are interdependent, the aim is to develop a scalable solution addressing all problems simultaneously in both technologies. The current solutions are evaluated, and the requirements in the hybrid network are analyzed. Solutions based on extensions to existing protocols (in particular DNS) and combinations of these are developed and finally evaluated.

Jose Costa-Requena Service Discovery enabling Ad Hoc networks connectivity

The thesis analyses the routing, the addressing and the service discovery of IP networks, and analyzes the evolution of wireless IP networks towards ad hoc networks. Seamless connectivity and inter-operability based on service discovery is proposed. Ad hoc networks are included as an extension of the wireless IP networks. A testbed including a routing framework and a VoIP application is implemented, and performance results are presented.

Riikka Susitaival Adaptive Traffic Engineering in MPLS and OSPF Networks

The thesis studies load balancing in both MPLS and OSPF networks based on measured link loads. An adaptive and distributed algorithm

for both types of networks is proposed. The algorithm gradually balances the load by making small changes in the traffic splitting ratios of the paths or the routers. The functioning of the algorithm is verified by numerical tests under different networks and traffic conditions. The tests demonstrate that in MPLS networks the adaptive algorithm converges rapidly almost to the optimum. Also in OSPF networks the improvement is significant as compared to equal splitting.

Yan Zheng Methodologies and Mechanisms for Building up a Trusted Mobile Environment

This thesis deals with security issues in mobile environment. In particular, the thesis discusses about how to build a trusted mobile environment in order to support various mobile applications and services. A conceptual architecture of the trusted mobile environment is first given and then a design methodology for it is presented. Furthermore various trust mechanisms are evaluated and trust management is discussed.

Masters of Science

The employers of our Master's thesis students are shown in Figure 4.2.

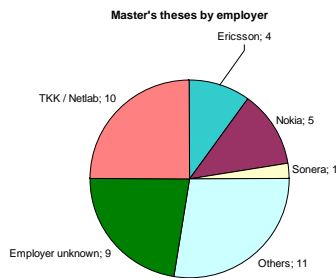


Figure 4.2: Employers of Master's thesis students 2004

- Ahola, Hannu: Planning the Implementation of Quality of Service in Multi-Protocol Label Switched Networks, Radiolinja Aava Oy
- Broman, Arne: X-509-Varmennepalvelun tuotantoketjun kokoaminen
- Chaichee, Skander: Functionality and Testing of Policy Control in IP Multimedia Subsystem, Nokia Networks
- Grahnström, Karl: Keys to successful and profitable software subcontracting in telecommunications industry
- Gröhn, Antti: Testiverkon kellosynkronointi, TKK, NetLab

- Hakkarainen, Pertti: WAP Downlink Performance Evaluation in UMTS Network, Nokia Networks
- Hintikka, Heikki: Voice over IP over Wireless Local Area Network, Song Networks Oy
- Jaakola, Esa: Taideteollisen korkeakoulun langattoman lähiverkon suunnittelu olemassa olevan lähiverkon rinnalle, Taideteollinen korkeakoulu
- Juneja, Antti: Testing framework for the service provisioning platform, Comptel Corporation
- Jylhä, Matti: Improvements to Service Provisioning Platform Deployment Process
- Kalm, Juha: Langattomien verkkojen tietosuojapalvelut
- Kiiski, Mikko: The effects of new mobile services on UMTS network structures, Suomen 3G Oy
- Kiviluoto, Antti: Application Integration in Intranets and Extranets, FRIENDS Technology Inc.
- Kumra, Sunesh: Load Balancing in IP Protocols
- Laukka, Arto: Evaluation of an internet protocol security based virtual private network solution, TeliaSonera Finland Oyj
- Lehtonen, Mikko: Economics of automation in functional testing of network service platforms, Nokia Networks
- Lemminkäinen, Tuomas: Centralized Configuration Management of Distributed System on Value-added Service Platform, Tecnomen Corp.
- Leppälahti, Jarkko: Improvement of Project Resourcing in a Software Company
- Liu, Shuping: Data Traffic Performance Analysis of a Cellular System with Finite User Population, TKK, NetLab
- Merger, Mikko: Liikkuvuudenhallinta Mobile IP versio 6-protokollalla, TKK, NetLab
- Miettinen, Antti: H.248 Gateway Control Protocol Signaling Traffic Related Protocol Analysis, Oy L M Ericsson Ab
- Muittari, Ari: Vulnerabilities in the Internet Key Exchange (IKE) Protocol, Nokia Networks
- Nordlund, Mikko: Impact of Personal Media Devices on Video Distribution Value Nets, Nokia Corp.
- Piironen, Markku: Evaluation of Signal Processing Resource Management Algorithms in 3G

- Pitkänen, Mikko: Transient States in Open Shortest Path First, TKK, NetLab
- Pulkkinen, Piia: Design and Implementation of a Policy Control Agent for a Differentiated Services Router, TKK, NetLab
- Purra, Tero: Laskentamalli ICT-järjestelmien kokonaiskustannusten arviointiin
- Rantala, Jatta: Third Party Service Provisioning in Session Initiation Protocol-based UMTS Network
- Santajärvi, Sanna: Real-Time IP Network Redundancy in Connection to Mobile Media Gateway, Oy L M Ericsson Ab
- Sarala, Risto: Linkkien tilaan perustuvan reititysprotokollan suorituskykyanalyysi, TKK, NetLab
- Siivola, Leena: Signaled Provisioning of the IP Network Resources between the Media Gateways in Mobile Networks, Oy L M Ericsson Ab
- Suhonen, Jari: Multimedia Technology Solution for Socially Isolated Aged Person, Institut Eurecom
- Suominen, Mikko: Enhancing System Capacity and Robustness by Optimizing Software Architecture in a Real-time Multiprocessor Environment, Oy L M Ericsson Ab
- Suominen, Niko: Autoconfiguration Alternatives and Service Architectures in Ad Hoc Networks, TKK, NetLab
- Tiistola, Jaakko: Prioritisation and Flow Control in Messaging Middleware
- Tuominen, Olli: Secure Shell in a clustered single-point-of-contact corporate environment
- Uljas, Mikko: Monitoring and System Management in Distributed Environment
- Wang, Yin: Adding Multi-Class Routing into the Differentiated Services Architecture, TKK, NetLab
- Viipuri, Timo: Traffic Analysis and Modeling of IP Core Networks, TKK, NetLab
- Viskari, Janne: Pakettipohjaisten puhelinratkaisujen soveltuvuus yliopisto- ja ammattikorkeakouluyhteisössä, TKK, NetLab

5 ACTIVITIES

5.1 Participation in conferences and meetings

- Samuli Aalto
 - COST 279 Mid Term Seminar, January 21-22, 2004 and COST 279 Management Committee Meeting, January 23, 2004, Rome, Italy
 - ACM/Sigmetrics Performance 2004 Conference, New York, USA, June 12-16, 2004
- Johanna Antila
 - E-NEXT Plenary and QoFIS'04 Workshop, Barcelona, Spain, September 27 - October 1, 2004
 - MIPS'2004 Conference, Grenoble, France, November 16-19, 2004
- Mohammad A Ayyash
 - MobileMAN Meeting, Pisa, Italy, September 29 - October 2, 2004
- Nicklas Beijar
 - MobileMAN Meeting, Cambridge, U.K., March 22-24, 2004
 - MobileMAN Meeting, Pisa, Italy, June 28 - July 3, 2004
- Jose Costa-Requena
 - 11th International Conference on Telecommunications ICT'2004, Fortaleza, Brazil, August 1-6, 2004
 - MobileMAN Meeting, Brussels, Belgium, October 20-21, 2004
 - CIIT 2004 (The 3rd IASTED International Conference on Communications, Internet, and Information Technology), St. Thomas, Virgin Islands, USA, November 22-24, 2004
- Jarrod Creado
 - MobileMAN Meeting, Pisa, Italy, June 24-29, 2004
- Esa Hyttiä
 - The ninth IEEE Symposium on Computers and Communications (ISCC'2004), Alexandria, Egypt, June 29 - July 1, 2004
 - SPECTS'04 (International Symposium on Performance Evaluation of Computer and Telecommunication Systems), San Jose, California, USA, July 25-29, 2004

- NTS'17 (17th Nordic Teletraffic Seminar), Fornebu, Norway, August 25-27, 2004
- Heikki Hämmäinen
 - ECOSYS Meeting, Paros, Greece, June 21-24, 2004
 - ITS-Europe, 15th Biennial Conference, ("Connecting societies and markets: communication technology, policy and impacts"), Berlin, Germany, September 4-7, 2004
 - 1st International CICT Conference, Lyngby, Denmark, November 4-5, 2004
- Mika Ilvesmäki
 - E-NEXT Plenary meeting, Madrid, Spain, February 25-26, 2004
- Daniel Jaskiewicz
 - WIDENS Project meeting, Paris, France, December 9-10, 2004
- Ilmari Juva
 - NTS'17 (17th Nordic Teletraffic Seminar), Fornebu, Norway, August 25-27, 2004
- Renjish Kaleelazhicathu
 - NEW2AN Conference, St Petersburg, Russia, February 2-6, 2004
 - ECOSYS Meeting, Oslo, Norway, February 25-26, 2004
 - ECOSYS Meeting, Lannion, France, April 20-23, 2004
 - ECOSYS Meeting, Paros, Greece, June 21-24, 2004
 - ECOSYS Meeting, Brugge, Belgium, September 6-9, 2004
 - ECOSYS Meeting, Madrid, Spain, October 20-22, 2004
 - ECOSYS Meeting, Oslo, Norway, December 13-15, 2004
- Raimo Kantola
 - The Fourth IEEE International Conference on Peer-to-Peer Computing, Zurich, Switzerland, August 25-27, 2004
 - EAIE 2004 Conference, Torino, Italy, September 15-18, 2004
- Jouni Karvo
 - WIDENS Kick-off meeting, Paris, France, March 2-4, 2004
 - WIDENS Project meeting, Sophia-Antipolis, France, April 13-15, 2004
 - WIDENS Project meeting, Barcelona, Spain, September 16-17, 2004

- WIDENS Project meeting, Paris, France, December 9-10, 2004
- Annukka Kiiski
 - ITS-Europe, 15th Biennial Conference, ("Connecting societies and markets: communication technology, policy and impacts"), Berlin, Germany, September 4-7, 2004
- Henri Koskinen
 - Euro-NGI Project meeting, Paris, France, February 17, 2004
 - Euro-NGI, Spatial Stochastic Modelling Workshop, Edinburgh, U.K., June 9-12, 2004
 - NTS'17 (17th Nordic Teletraffic Seminar), Fornebu, Norway, August 25-27, 2004
 - 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems, Antwerp, Belgium, August 31 - September 2, 2004
 - First Euro-NGI Summer School 2004, Bamberg, Germany, September 27 - October 1, 2004
 - ACM MSWiM 2004, Venice, Italy, October 4-6, 2004
- Pasi Lassila
 - NETWORKING 2004, Athens, Greece, May 9-14, 2004
 - 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems, Antwerp, Belgium, August 31 - September 2, 2004
 - COST 279 Management Committee Meeting, Ghent, Belgium, September 23-24, 2004
- Juha Leino
 - First Euro-NGI Summer School 2004, Bamberg, Germany, September 27 - October 1, 2004
- Olmo León
 - MobileMAN Meeting, Pisa, Italy, June 24-29, 2004
- Marko Luoma
 - E-NEXT Plenary meeting, Madrid, Spain, February 25-26, 2004
 - 3rd International Conference on Networking, ICN'2004, Guadeloupe, French Caribbean, February 29 - March 1, 2004
 - E-NEXT WG4 Meeting, Paris, France, April 15-16, 2004
 - E-NEXT Plenary and QoFIS'04 Workshop, Barcelona, Spain, September 27 - October 1, 2004

- Marcin Matuszewski
 - 12th International Conference on Telecommunication Systems, Modeling and Analysis, Monterrey, CA, USA, July 22-25, 2004
 - ATNAC 2004 Conference, Sydney, Australia, December 8-10, 2004
- Jarmo Mölsä
 - CIIT 2004 (The 3rd IASTED International Conference on Communications, Internet, and Information Technology), St. Thomas, Virgin Islands, USA, November 22-24, 2004
- Aleksi Penttinen
 - Euro-NGI IA.8.3., Dagstuhl Workshop on Mobility and Wireless, Dagstuhl, Germany, June 7-9, 2004
 - IEEE Conference MASS 2004, Fort Lauderdale, Florida, USA, October 24-27, 2004
- Markus Peuhkuri
 - E-NEXT WG4 Meeting, Paris, France, April 15-16, 2004
 - PAM2004 (The 5th annual Passive Active Measurement Workshop), Antibes Juan-les Pins, France, April 19-20, 2004
- Mikko Pitkänen
 - ICEIS 2004, 6th International Conference on Enterprise Information Systems, Porto, Portugal, April 13-17, 2004
- Timo Smura
 - ECOSYS Meeting, Brugge, Belgium, September 6-9, 2004
 - ECOSYS Meeting, Madrid, Spain, October 20-22, 2004
 - CICT Conference 2004, Lyngby, Denmark, November 4-5, 2004
 - ECOSYS Meeting, Oslo, Norway, November 23-24, 2004
 - ECOSYS Meeting, Oslo, Norway, December 13-15, 2004
- Riikka Susitaival
 - Euro-NGI Project meeting, Paris, France, February 18, 2004
 - Euro-NGI Project meeting, Rome, Italy, April 22-23, 2004
 - HET-NETs'04 Conference (Performance Modelling and Evaluation of Heterogeneous Networks), Ilkley, U.K., July 26-28, 2004
 - MMB&PGTS 04 Conference, Dresden, Germany, September 12-15, 2004

- Piia Töyrylä
 - IASTED International Conference on Parallel and Distributed Computing and Systems (PDCS 2004), MIT, Cambridge, USA, November 9-11, 2004
- Jorma Virtamo
 - COST 279 Mid-Term Seminar and Management Committee Meeting, Rome, Italy, January 21-23, 2004
 - NETWORKING 2004, Athens, Greece, May 9-14, 2004
- Shushan Zhao
 - WIDENS Project meeting, Paris, France, December 9-10, 2004

5.2 Academic activities

- Jorma Virtamo
 - Opponent in Dr.Tech. dissertation, NTNU, Trondheim, Norway, February 23-24, 2004

5.3 Visits abroad

- Samuli Aalto
 - Participating in Research Programme 'Queueing Theory and Teletraffic Theory' in Institut Mittag-Leffler, Stockholm, Sweden, August 31 - October 8, 2004
- Esa Hyytiä
 - Visiting researcher, Debrecen, Hungary, October 1-10, 2004
- Heikki Hämmäinen
 - Visiting lecturer in École National d'Ingenieurs de Tarbes, Tarbes, France, September 13-16, 2004
- Eeva Nyberg-Oksanen
 - Visiting researcher, Institut National de Recherche en Informatique et en Automatique (INRIA), Sophia-Antipolis, France, February 10-28, 2004
- Aleksi Penttinen
 - Visiting researcher, University of Thessaly, Volos, Greece, September 13 - December 9, 2004
- Jorma Virtamo
 - Participating in Research Programme 'Queueing Theory and Teletraffic Theory' in Institut Mittag-Leffler, Stockholm, Sweden, August 31 - October 8, 2004

5.4 Foreign visitors in 2004

The laboratory had the honor to host the following visits:

- Borgia, Eleonora from Consiglio Nazionale delle Ricerche (CNR), Italy
- Daoud, Fawzi from Tokyo University, Japan
- Delmastro, Franca from Consiglio Nazionale delle Ricerche (CNR), Italy
- Diaz, Pedro from Universidad Politécnica de Madrid, Spain
- Fialka, Ondrej from Czech Technical University in Prague, Czech
- Garcia Sánchez, Javier from Universidad Politécnica de Madrid, Spain
- León Cadahia, Olmo from Universidad Rey Juan Carlos, Spain
- Ruiz Quintana, Yalton from Universidad Politécnica de Madrid, Spain
- Rutkovszky, Edéné from University of Debrecen Hungary
- Sánchez Rodrigues, Vanessa from Universidad Politécnica de Madrid, Spain
- Schmid, Emanuel from ETHZ - Federal Institute of Technology, Switzerland
- Sztrik, János from University of Debrecen, Hungary
- Tari, Árpád from Budapest University of Technology and Economics, Hungary
- Vaton, Sandrine from École Nationale Supérieure des Télécommunications de Bretagne, France
- The following NETS group from Japan:
 - Hanamura, Tsuyoshi
 - Isobe, Shunkichi
 - Matsumoto, Mitsuji
 - Sasase, Iwao
 - Satoh, Ichiro
 - Yamazato, Takaya
 - Yoshida, Susumu
 - Inoue, Masugi
 - Kawaguchi, Nobuo
 - Ohta, Genichiro
 - Sato, Takuro
 - Teraoka, Fumio
 - Yoneyama, Tsukasa

6 PARTICIPATION IN BOARDS AND COMMITTEES

6.1 University boards and committees

- Arja Hänninen
 - Member of the Work Committee planning concept for TKK websites
- Raimo Kantola
 - Director of the Master's Programme in Telecommunications
 - Director of International Study Affairs at the Department of Electrical and Communications Engineering
 - Member of the Degree Programme Council at the Department of Electrical and Communications Engineering
 - Member of Strategy group at the Department of Electrical and Communications Engineering
 - Member of Faculty Council at the Department of Electrical and Communications Engineering
- Markus Peuhkuri
 - Member of Committee of Post Graduate School at Department of Electrical and Communications Engineering
- Kirsi Willa
 - Member of Committee for Qualitative Development of Teaching at Department of Electrical and Communications Engineering

6.2 Other boards and committees

- Heikki Hämmäinen
 - Member of Board, NETS Future Networks Program, TEKES
 - Member of Local Organizing Committee, Information Technology, World Championships in Athletics, Helsinki 2005
 - Member of Technical Program Committee, International Conference on Information & Communication Technologies: From Theory to Applications, ICTTA'04
 - Member of Program Committee, International Telecommunication Society, Biennial Conference 2004
 - Member of the Board of the Research Foundation of Helsinki Telephone Company

- Jorma Jormakka
 - Member of the scientific council of the National Defence College
- Raimo Kantola
 - Technology Advisor to the Board of CSC Scientific Computing Ltd
 - Member of the Broadband Networks Thematic Group in the TEKES NETS program
 - Member of the Board of the Graduate School on Networks for Information Society
 - Member of the Technical Program Committee of the First International Workshop on QoS Routing.
- Marko Luoma
 - Member of the Technical Program Committee of the workshop on Quality of Future Internet Services, QoFIS'03, Stockholm, Sweden
 - Member of the Board of Creanord Oy
- Jorma Virtamo
 - Member of IFIP Working Group 6.3, Performance of Communication Systems
 - Member of the Board of the Finnish Graduate School in Stochastics
 - Member of the Technical Program Committee of Networking 2004, Athens, Greece, May 9-14, 2004
 - Member of the Technical Program Committee of ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems, Antwerp, Belgium, August 31 - September 2, 2004
 - Member of the Scientific Steering Committee of Institut Mittag-Leffler, The Royal Swedish Academy of Sciences, Program in Queueing Theory and Teletraffic Theory, Fall 2004
 - Member of the Technical Program Committee of 19th International Teletraffic Congress ITC-19, Beijing, China, August 29 - September 2, 2005
 - Member of the Technical Program Committee of the Euro-NGI 2005 Conference, Rome, Italy, April 18-20, 2005

6.3 Referee activities

- Samuli Aalto
 - Reviewer for the the following scientific journal: Journal of Communications and Networks
 - Reviewer for the following conferences: HET-NETs'04, Euro-NGI 2005

- Johanna Antila
 - Reviewer for IEEE/ACM Transactions on Networking
- Esa Hyytiä
 - Reviewer for ISCC 2004 and Euro-NGI 2005 conferences
 - Reviewer for the Computer Journal
- Heikki Hämmäinen
 - Reviewer for the following conferences: ICTTA 2005, ITS 2004, 10th IEEE Symposium on Computers and Communications
- Jorma Jormakka
 - Reviewer for the following scientific journals: Networking 2004 (cont.), EPMCC'03 (cont.)
- Raimo Kantola
 - Reviewer for Journal of Computer Communications
 - Reviewer for IEEE Journal on Selected Areas in Communications
 - Reviewer for IEEE Communications Magazine
 - Reviewer for First International Workshop on QoS Routing (WQoS'R'04)
 - Reviewer for Nordic Radio Symposium/Finnish Wireless Communications Workshop 2004
- Jouni Karvo
 - Reviewer for the following conferences: QoFIS 2004, Networking 2004
- Henri Koskinen
 - Reviewer for the 16th ITC Specialist Seminar (ITCSS-16)
- Pasi Lassila
 - Reviewer for the following conferences: Networking 2004, 16th ITC Specialist Seminar, WQoS'R 2004
- Marko Luoma
 - Reviewer for the following scientific journals: Elsevier Computer Communications, IEE Electronic Letters, IEE Proceedings in Communications
 - Reviewer for the QoFIS'2004 conference

- Aleksi Penttinen
 - Reviewer for NETWORKING 2004, Third International IFIP-TC6 Networking Conference
 - Reviewer for the 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems
- Jorma Virtamo
 - Reviewer for the following scientific journals: Queueing Systems, Telecommunication Systems, Annals of Telecommunications, Journal of Computer Communications
 - Reviewer for the following conferences: Networking 2004, ITC Specialist Seminar, Euro-NGI 2005, HET-NETs 2004

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A MESSAGE BY RECTOR PURSULA AT THE NETLAB'S ANNIVERSARY

Tietoverkkolaboratorion juhlaseminaari
Matti Pursula 12.3.2004

ARVOISAT JUHLASEMINAARIN OSANOTTAJAT!

Olemme kokoontuneet juhlimaan TKK:n tietoverkkolaboratorion 60-vuotista taivalta ja 1000:tta diplomityötä. Laboratorion työ alkoi aikanaan heikkovirtatekniikan laboratoriona, jatkui puhelintekniikan ja teletekniikan laboratoriona ja siirtyi uudelle vuosituhannelle tietoverkkolaboratoriona. Saamani tiedon mukaan alan ensimmäinen diplomityö on tehty jo noin 80 vuotta sitten.

Laboratorion keskeiset professorit ovat olleet Jaarli Jauhiainen ja Kauko Rahko. Professori Jauhaisen johti laboratoriota vuosina 1945 - 1969 ja hänen syntymästään tulee kuluneeksi sata vuotta. Professori Rahko oli laboratorion esimiehenä vuosina 1970 - 1996. Näiden professorien oppilaat ovat olleet keskeisellä tavalla mukana luomassa ja kehittämässä suomalaista tietoliikenneinfrastruktuuria, ensin lankaverkkoon perustuvia yhteyksiä ja myöhemmin langattomia yhteyksiä. Laboratorion toiminta on omalta osaltaan esimerkki Teknillisen korkeakoulun opetuksen ja tutkimuksen vahvasta yhteiskunnallisesta vaikutuksesta.

Tänään laboratoriossa on neljä professoria ja runsaasti opiskelijoita. Viime vuonna valmistui saamieni tietojen mukaan 51 diplomi-insinööriä ja 2 tekniikan tohtoria. Nämä luvut kuvastavat hyvin laboratorion nykyistä tilannetta. Perustutkintoja valmistuu runsaasti, mutta tohtorikoulutus vaatii vielä kehittämistä. Suuri perusopetuskuorma sitoo huomattavasti resursseja, joita tarvittaisiin myös tohtorikoulutukseen. Hyvä työllisyystilannekin luultavasti vähentää kiinnostusta tohtorikoulutukseen.

Tietoverkkolaboratorion resurssitilanne on tuttu myös monissa muissa sähkö- ja tietoliikennetekniikan osaston ja tietotekniikan osaston laboratoriossa. IT-sektorin koulutuspaikkojen suuri lisäys 90-luvun lopulla johti resurssiongelmien, varsinkin, kun myös opettajia oli vaikea saada. Nyt tilanne lienee jo osittain korjautunut, koska opiskelijoiden sisäänottoa on supistettu ja alalle on saatu koulutettua uusia tieteellisesti päteviä opettajavoimia. Tosin 90-luvun lopun suurten vuosiluokkien oppilaat ovat vasta tulossa diplomityövaiheeseen, joten kuormitus ei vielä muutama vuoteen tasaannu.

Teknillisessä korkeakoulussa on käynnistetty rakenteelliseen kehittämiseen tähtäävä keskustelu. Yksi sen keskeinen kysymys on, miten suuri IT-sektorin koulutuksen tulee olla absoluuttisesti ja suhteessa muihin korkeakoulun toimialoihin. Tänään IT- sektori on lähes 40 % sisäänotosta ja professorikun-

nasta. Naapurissamme KTH:lla IT-alan professorien osuus kaikista on noin 20 %, samoin Aachenissa. Imperial Collegessa Lontoossa osuus noin 28 %, samoin MIT:ssa ja ETHZ:ssa noin 30. Toki tällaiset vertailut ovat aina vaikeita, jos ne tehdään vain pikaisesti tilastojen perusteella, mutta yhtä kaikki, TKK on tänään vahvasti IT-orientoitunut yliopisto. Opetuksemme rakenneuutos heijastaa myös suomalaisen teollisuuden rakennemuutosta, sillä IT sektorin osuus TKK:sta vuonna 1993 oli vain noin 23 %.

Kun tavoitteemme on laskea opiskelijamäärää vielä noin 200:lla (netto-sisäänotto 1 340, vuonna 2003 1 530 opiskelijaa), on samalla pohdittava kysymystä, muuttuvatko eri koulutusalojen suhteet TKK:lla seuraavien 10 vuoden kuluessa. Tämä on siis yksi keskeisistä yliopistomme rakenteiden kehittämisen kysymyksistä. Tietoliikennetekniikan asema alan koulutuksessa on kuitenkin keskeinen, joten mahdollisissa muutoksissakin tuntuu todennäköiseltä, että sen resursointi pikemminkin paranee kuin heikkenee.

TKK:ssa on menossa tutkinnonuudistus, jossa siirrymme yleiseurooppalaiseen kaksiportaiseen tutkintorakenteeseen. Tutkinnonuudistus antaa meille mahdollisuuden joustaviin aineyhdistelmiin ja nykyistä tehokkaampaan opetukseen. Vieraskielisen opetuksen järjestämien DI-tasolle eli ylempään kaksivuotiseen tutkinto-ohjelmaan parantaa edelleen IT-alan mahdollisuuksia kansainvälisten opiskelijoiden rekrytointiin, joka jo nyt on ollut erittäin menestyksekkästä. Parin viime vuonna vieraskielisten perustutkintojen määrä TKK:ssa on ollut yli 5 % kaikista ja tohtorikoulutuksessa reilusti yli kymmenen prosenttia.

Olen edellä hieman kerrannut tietoverkkolaboratorion historiaa ja hahmoitellut Teknillisen korkeakoulun sisäisen rakenteellisen kehittämisen ajankohtaisia kysymyksiä. Tänään on kuitenkin syytä kiittää tietoverkkolaboratorion henkilökuntaa sen menestyksekkästä työstä TKK:n ja suomalaisen yhteiskunnan hyväksi. Laboratorio voi katsoa luottavaisuuteen, alan koulutukselle ja tutkimukselle on tarvetta ja alan tärkeys tiedostetaan sekä TKK:ssa että ympäröivässä yhteiskunnassa.

Kiitän tilaisuudesta tuoda tähän juhlaan TKK:n tervehdys ja toivotan onnea ja menestystä juhlivalle laboratoriolle! Aloittakaamme juhlinta luovuttamalla DI Mikko Kiiskille kunniakirja laboratorion 1000:nneen diplomityön kunniaksi.

Kiitos

B MESSAGE BY PROFESSOR KANTOLA AT THE NETLAB'S ANNIVERSARY

Tietoverkkolaboratorion tulevaisuuden näkymät

Laboratorion 60-vuotisjuhlaseminaari 12.3.2004
Professori Raimo Kantola

Herra Rehtori, Arvoisat Kutsuvieraat, hyvät Naiset ja Herrat,

Viime vuosikymmenellä tietoteollisuus nousi Suomen talouden kolmanneksi tukijalaksi. Tietoteollisuuden viennistämme suurin osa on tietoliikennelaitteita. Samaan aikaan yritysten liiketoimintaprosessit rakentuvat yhä tiukemmin tietoverkkojen ympärille.

Laboratoriomme kouluttaa asiantuntijoita vientiteollisuuden ja luonnollisesti tietoverkko-operaattoreiden tarpeisiin, mutta myös kaikille sellaisille yrityksille, jotka hyödyntävät tietoverkkoja.

Viime kuukausina lehdet ovat kertoneet tietoteollisuuden irtisanomisista, insinöörien kasvavasta työttömyydestä, teollisten työpaikkojen paosta Kiinaan ja siitä, kuinka tietotyö, mukaan lukien ohjelmistosuunnittelu, muuttaa Intiaa. Kiinassa ja Intiassa koulutetaan miljoonia uusia insinöörejä vuosittain.

Aasian nousevien talouksien kilpailu onkin Suomelle valtava haaste. Tulevaisuutemme on pelissä. Haaste on pakko ottaa vastaan.

Tätä taustaa vasten, aivan oikeaan aikaan, Rehtori on käynnistänyt keskustelun TKK:n rakenteellisesta kehittämisestä. Tarkoitus on selvittää yliopistomme koulutukselliset tavoitteet vuosikymmenen loppuun samalla, kun hahmotamme tulevaisuutta aina vuoteen 2020.

Pyrin tässä tuomaan esille seikkoja, joiden uskon antavan suuntaa tietoteollisuuden kehitykselle ja erityisesti tietoverkko-osaamisen tarpeen arvioinnille tulevana vuosikymmenenä.

Ensinnäkin meidän kannattaa muistaa, että tiedolle ei ole korviketta lisäarvon lähteenä yltäkylläisyyden maailmassa, jonka olemme rakentaneet. Vain lisäämällä tuotteiden tietosisältöä, menestyminen markkinoilla on mahdollista. Ne, jotka siinä onnistuvat parhaiten, ansaitsevat selvästi yli keskiarvon nousevia katteita pitkällä aikavälillä. Siksi uskon, että Suomella ei ole vaihtoehtoa tiedon merkitystä korostavalle politiikalle.

Tietoverkko-osaamisen tarpeen tasoittumista puoltavat kuitenkin seuraavat seikat.

Podemme edelleen vuosituhannen vaihteen hypen jälkikrapulaa. Sijoittajat rankaisivat nyt meitä menettämistään pääomista ja tuhoutuneista unelmista. Taajuushuutokauppojen jälkeisen investointilaman jälkeen hankinnat julkisiin tietoverkkoihin ovat vasta nyt käynnistymässä. On syytä suodattaa tämän väliaikaisen krapulan vaikutus pois, kun arvioimme pitkän aikavälin kehitystä. Tietoliikenne perustuu jatkossa globaaleihin standardeihin. Kyse ei enää ole markkinoiden jaosta Suomen ja Ruotsin kesken, kuten GSM:ssä, vaan vastassamme ovat niin amerikkalaiset, japanilaiset kuin kiinalaiset ja saksalaiset ja muut eurooppalaiset yritykset. Kysymys kuuluu: minkä markkinaosuuden kykenemme valtaamaan näillä globaaleilla markkinoilla. Mooren lain mukaan laukkaava tekninen kehitys on törmännyt vanhojen arvoketjujen muutoksen ja ihmisten omaksumiskyvyn hitauteen. Laajakaistaverkko olisi mainio ja tehokas jakelukanava kaikelle digitaaliselle tiedolle, mutta sisältöteollisuus on ollut hidas hyväksymään muutosta. Paluuta entiseen ei kuitenkaan ole.

Mitkä seikat puolestaan puhuvat tietoverkko-osaamisen kasvavasta tarpeesta yhteiskunnassa? Tällaisia seikkoja on paljon:

Yhä uudet liiketoimintaprosessit tukeutuvat tietoverkkoihin. Kaikki isot yritykset käyttävät sitä osaamista, jota me tietoverkkolaboratoriossa kehitämme. Yhä uudet perinteiset alat ryhtyvät hyödyntämään tietoverkkotekniikkaa omissa järjestelmissään. Uusia langattomia verkkoja kehitetään ja otetaan käyttöön. (Tärkeimpiä ovat 3. sukupolven matkaviestinverkot, langattomat lähi- ja metropoliverkot ja uudet kehitteillä olevat lyhyen kantaman radioverkot.) Tuota pikaa meillä on aina mukanaamme personoitava moniviestin, joka liittyy nopeaan langattomaan verkkoon ja mahdollistaa puhelut, turvallisen dataviestinnän, kuvan siirron ja viihteen seurannan. Laite on luotettava apuri tietotuotteiden ostamisessa ja kuluttamisessa. Tuekseen laite tarvitsee tehokkaan tietoverkon ja sen rikkaat palvelut. On vain ajan kysymys, milloin myös sisältöteollisuus ottaa laajakaistaverkot omaksi jakelutieksi. Tämä nostaa tietoverkkojen liikennemäärät monisatapäivästä monituhattakertaisiksi. Tässä riittää haastetta tietoverkkoammattilaisille pitkäksi aikaa. Kehityksen sosiaaliset ja kulttuuriset vaikutukset ovat merkittäviä. Laajakaistaverkko muuttaa sähköistä mediakenttää. Broadcastingin rooliksi jää välittää uutisia 24 tuntia vuorokaudessa ja urheilua suorina lähetyksinä. Muun sisällön valitsemme itse, silloin kun haluamme sitä seurata ajasta riippumatta. Tämä muuttaa Internetin sähköisen median jakelutieksi. (Jo muutaman vuoden päästä kotimme on liitetty Internetiin megabittinopeudella. Kodin sisällä tieto liikkuu joko langattomasti tai kaapeleissa kaikkien kodin elektroniikalaitteiden kesken.)

On vain ajan kysymys, milloin alamme vetää valokuituja joka kotiin. Tarkeemmin sanottuna kyse on siitä, vedetäänkö niitä aikaisemmin Suomeen kuin Kiinaan ja Intiaan. Näin siitä huolimatta, että viikoittain saamme kuunnella virkamiehiä, jotka on marssitettu julkisuuteen valittamaan kuinka kallista kuidun vetäminen on. Valittajilta on jäänyt huomaatta, että kuitu on halpaa verrattuna esim. kaikkiin niihin elektroniikkahankintoihin, jotka teemme koteihimme tällä vuosikymmenellä.

Edellä kuvaamani seikat liittyvät tietoverkko-osaamisen kotimaiseen kysyntään. Mitä voimme sanoa tietoverkko-osaamista hyödyntävästä vientiteollisuudesta?

Ensinnäkin tämän vuosikymmenen tietoteollisuuden Titaanien taistelussa Nokian lähtöasetelma on moninkertaisesti vahvempi kuin se oli 10 vuotta sitten. Mobiilisuus on yksi tämän vuosikymmenen merkittävä elektroniikkateollisuuden muutosvoima. Mobiiliteetti tekee tietoverkoista kertaluokkaa monimutkaisempia. Siksi järjestelmäosaamisen merkitys esim. kolmannessa sukupolvessa vrt GSM:ään vain kasvaa. Tietoverkkotekniikka on juuri sitä järjestelmäosaamista, jonka avulla verkot saadaan toimimaan. Tämän lisäksi keskeistä on terminaaleihin liittyvä syvä tietotekninen, elektroniikka ja järjestelmäosaaminen. Nokian asema on myös haastavampi kuin 10 vuotta sitten. Yllättäjästä se on muuttunut kohteeksi, jota vastassa ovat maailman vahvimmat tietoyritykset. Tietoteollisuudessa voimme ulkoistaa jo hyvin oppimamme tuotannon vaikka Kiinaan ja alihankkia ohjelmistoja Intiasta. Järjestelmäosaamisesta Nokia tai mikään muukaan kehittyneen teollisuusmaan johtava tietoyritys ei voi luopua. Sen mukana menee nimittäin kaikki. Koska tietoverkkoalan yritykset toimivat globaaleilla markkinoilla, järjestelmäosaamisen rinnalla korostuu osaamisen laatu. Vain paras voi pärjätä. Meidän on koulutettava jo diplomi-insinööreistä paitsi yliverlaisia järjestelmäosaajia myös taitavia ajatusten kauppiata. Uusi tekniikka syntyy globaaleissa standardointielimissä ja teollisuusfoorumeilla. Meiltä valmistuneiden diplomi-insinöörien ja tohtoreiden tulee pystyä toimimaan näillä foorumeilla yhtä tehokkaasti kuin Koti-Suomessa. Tohtorikoulutuksen lisäksi, tämä korostaa koulutuksen kansainvälisyyttä, opiskelijavaihtoa ja kotikansainvälistymistä jo täällä Otaniemessä. Uuden tekniikan omaksumisen hidasteista seuraa monitieteisen lähestymisen tärkeys. Ei riitä, että kykenemme suunnittelemaan maailman tehokkainta tekniikkaa teknisen determinismin hengessä. Meidän täytyy ymmärtää uusimman, vasta piirustuslaudalla olevan tekniikan, hyödyntämisen taloudelliset ja sosiaaliset edellytykset. Miten arvoketjujen on muututtava, jotta tekniikasta olisi hyötyä? Ovatko muutoksen edellytykset olemassa? Miten uusi tekniikka muuttaa elämäntapaamme? Miten teknologia käännetään liiketoiminnaksi? Parilta viime vuosikymmeneltä tunnemme joukon tekniikoita, jotka ovat olleet kehittäjilleen pettymyksiä. Tällainen on esim. ATM. Siitä ei tullut laajakais-taverkkojen tärkeintä tekniikkaa, se on päin vastoin väistymässä kokonaan. Synnä on mielestäni, että tekniikan suunnittelussa ei ymmärretty digitaalisen talouden arvonmuodostusta ja laajakaistan roolia arvoketjussa. Emme tarvitse tällaisia virheitä enää lisää.

Yhteenvetona voimme sanoa, että tietoliikenne on yksi globalisaation moottori. Ne maat, jotka ovat eturintamassa hyödyntämässä globaaleja tietoverkkoja, myös hyötyvät globalisaatiosta. Ne, jotka jäävät jälkeen, uivat ajopuina kehityksen virrassa. Suomi on tietoverkkolaitteiden viejä. Siksi tietoverkot ovat Suomen globalisaatiostrategiassa erityisen keskeisiä. Menestymisen kilpailussa on kiinni uuden osaamisen kehittämisestä. Tietoverkkotekniikka on tässä keskeistä järjestelmäosaamista, jossa meillä on paljon pelissä.

Tässä valossa en voi olla tarttumatta tilaisuuteen ja ilmaista huoleni kansallisesta kilpailukyvyistämme tietoverkkojen käytössä. Niin hampaaton on hallituksen valmisteleva kansallinen laajakaistastrategia ja niin huolellisesti se välttää tarttumasta oleellisimpiin ongelmiin.

Mitä tästä kaikesta seuraa Tietoverkkolaboratorion tulevaisuuden osalta?

Käsitykseni mukaan osaamistarve tietoverkkotekniikassa jakaantuu kahteen kategoriaan.

Ensinnäkin tarvitaan lisää insinöörejä, joiden varsinainen ammattitaito on jollakin muulla alalla, mutta jotka pystyvät hyödyntämään tietoverkkotekniikkaa erikoisalallaan ja hankkimaan lisäosaamista silloin, kun sitä tarvitaan.

Toisessa kategoriassa korostuu alan syvälinen järjestelmäosaaminen. Parhaat osaajat on syytä kouluttaa tohtoreiksi, jotta kykenemme määrittelemään tulevaisuuden tekniikkaa globaalissa kilpailussa. Voimme vastata tähän haasteseen vain kehittämällä tietoverkkojen monipuolista tutkimusta ja verkottamalla tiiviimmin kansainvälisesti.

Viime vuosien saavutuksiamme ovat mm. Tietoverkkolaboratorion Iro-Net tutkimusryhmän valinta TEKES:n NETS ohjelman kärkihankkeeksi. Olemme liittyneet kahteen EU:n rahoittamaan huippututkimuksen verkostoon.

Olemme aloittamassa uutta temaattista tutkijakoulua yhdessä Tietotekniikan osaston, Tampereen Teknillisen Yliopiston ja Maanpuolustuskorkeakoulun kanssa. Teemana on "Networks for Information Society". Koulu hakee monitieteistä otetta tulevaisuuden tietoverkkojen kehittämiseen.

Jo pitkän aikaa laboratoristamme on valmistunut noin 40...50 diplomi-insinööriä vuodessa. Henkilökohtaisesti valvomieni töiden määrä on vaihdellut 20 ja 30 välillä vuosittain. Laatuun panostaminen ja määrän tuottaminen yhtä aikaa on työlästä ja onnistuminen vaikeaa. Jatkossa meidän on välttämätöntä panostaa tohtorikoulutukseen entistä enemmän. Esittämieni seikkojen valossa odotan, että Laboratoriosta valmistuvien diplomi-insinöörien määrä pysyy suurin piirtein nykytasolla. Eri alojen tarve soveltaa tietoverkkotekniikkaa tuonee meille jatkossa lisää opetusvastuita. Näistä syistä tarvitsemme uusia professuureja. Erityisesti langattomien verkkojen tietoverkkotekniikka on TKK:lla luvattoman heikoissa kantimissa. Tähän pitää saada nopeasti korjausta.

(Kun alan teollisuus on kaivannut tietoverkkoalueelle tohtoreita, se on palannut esim. kylmälaboratoriosta valmistuneita fyysikoita, koska tietoverkkotekniikasta on väitelty niin harvoin ja viime vuosikymmenen aikana teollisuus imi parhaat tietoverkkoalan ihmiset sen sijaan että heistä monet olisivat jääneet jatko-opiskelijoiksi TKK:lle. Tietoverkkotekniikka on kuitenkin kypsymässä tutkimuksen alana. Jatkossa meidän on pyrittävä lisäämään tohtorikoulutustamme merkittävästi.)

Näen laboratoriomme tulevaisuuden valoisana. Yhteiskunnassamme ja teollisuudessamme on vahva kysyntä sille osaamiselle, jota kehitämme ja syvennämme. Selvästi on olemassa yhteiskunnallinen tilaus kansainvälisesti merkittävälle tietoverkkojen tutkimuslaitokselle, joka ei ole sidottu vallitseviin arvoketjuihin ja joka tutkii uutta verkkotekniikkaa monitieteisen lähestymistavan pohjalta. Tällaisen tutkimuslaitoksen on myös syytä osallistua alansa liittyvään yhteiskunnalliseen keskusteluun yliopistojen kolmannen tehtävän mukaisesti.

Pyrkikäämme rakentamaan tietoverkkolaboratoriosta tällainen teknistä huippuosaamista edustava, lahjakkaita nuoria houkutteleva, monitieteinen ja yhteiskunnallisesti aktiivinen tutkimuslaitos. Tämä edellyttää verkottumista niin TKK:n sisällä, kansallisesti kuin kansainvälisestikin.